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Research on ABS of Multi-axle Truck Based on ADAMS/Car and Matlab/Simulink

Zhang Xiu-qin[a,b], Yang Bo[a,b], Yang Chao[a,b], Xu Guan-neng[c]

[a]*School of Automotive Engineering,Luo-shi Road 205# Wuhan University of Technology, Wuhan 430070, China*

[b]*Hubei Key Laboratory of Advanced Technology of Automobile Parts, Luo-shi Road 205# Wuhan University of Technology, Wuhan 430070, China*

[c]*Institute of Guanxi auto & Tractor, Hexi Road 18# Liuzhou City, Liuzhou 545007, China*

Abstract

The anti-lock braking system based on multi-body dynamic and control theory is researched. Multi-body vehicle dynamic model is built in ADAMS/Car and suspension system, tire model, braking system, engine system, steer system, vehicle frame are included. The non-linear characteristics of tire, bushing, spring and damper is considered, so it can accurately express the dynamics performance of the vehicle. Besides, logic threshold control model of ABS based on wheel deceleration and slip rate is designed under Matlab/Simulink environment, and the two models are integrated and co-simulation by the interface of ADAMS/Control. Simulation results that based on different arrangement of ABS system are compared with general brake results. Analysis results indicate that vehicle braking performance is improved with shorter braking distance and less lateral displacement, so vehicle with ABS has much more practical significance.

Keywords: ABS, logic threshold control, slip rate, ADAMS/Car, Matlab/Simulink;

1. Introduction

Rigid truck has used widely with the development of national economy, and the speed of trucks is higher than before, so higher demand of braking performance is required. As saying in national standard: The gross mass more than 16t should be with ABS equipment[1]. The effective way to improve braking performance is to install ABS. Research of vehicle braking performance with ABS is experiment and computer simulation or combining them together. The method of experiment is always with long period、 high cost and risk. And computer simulation can avoid these disadvantages and provide experiment bases.

The research object is a three axle vehicle. The co-simulation is based on multi-body dynamic model that is established in ADAMS/Car software and logic threshold control antilock brake systems which is built

* Corresponding author. Tel.: +86-13627141869; fax: +027-87859247.
E-mail address: zxq0502170@163.com.

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in Matlab/Simulink. As non-linear characteristics of Multi-body mechanism has considered and logic threshold control is applied on braking system, the result of ABS co-simulation is effectual with different arrangements of ABS system. ABS co-simulation technology gives great help to ABS research on cost cutting[2,3].

2. whole vehicle dynamics model

• 2.1.vehicle model in ADAMS/Car

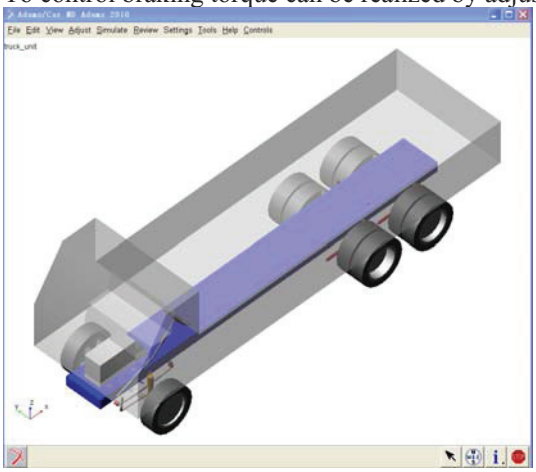
As precise virtual model is the basis of simulation, non-linear three-axle vehicle model is established in ADAMS/Car that suspension system, power train system, steering system, braking system, wheels system and frame system. The vehicle model is showed as picture 1 and special parameters are in table 1.

Table 1. Parameters of vehicle model

Totally degree of freedom	441
Number of moving link	136
Number of kinematic pair	93
Vehicle quality(kg)	11905
Overall dimensions length, width, height(mm)	10960, 2500, 3850
Wheel base(mm)	5350, 1300
Tread(mm)	1990,1860,1860

• 2.2. model of braking system

To control braking torque can be realized by adjusting wheel cylinder pressure. Through opening and



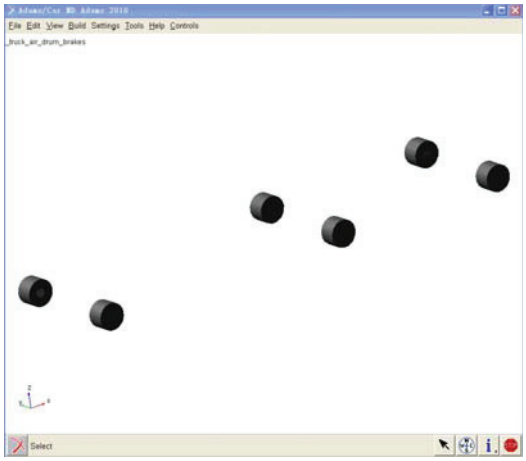


Fig. 1. vehicle model; Fig. 2. air drum brakes.

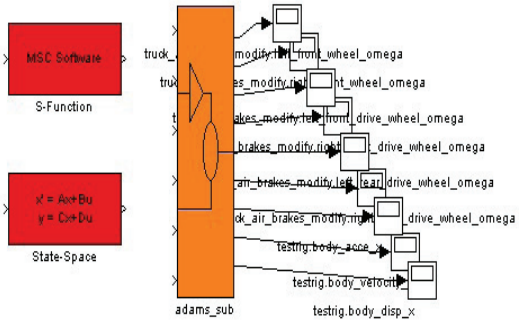
closing electromagnetic valve, braking pressure can exchange in these states---pressure build-up, pressure keeping, pressure-relief, therefore slip rate can be in a certain range[4]. Front and rear braking system are

air drum brakes, and just shows in picture 2.First of all, weighted coefficients of braking pressure should be defined in virtual model:
ABS_left_front_brake_pressure_input
ABS_right_front_brake_pressure_input
ABS_left_front_drive_brake_pressure_input
ABS_right_front_drive_brake_pressure_input
ABS_left_rear_drive_brake_pressure_input
ABS_right_rear_drive_brake_pressure_input

These six weighted coefficients are output of control model, and in the meanwhile are input of braking system. Braking torque is defined according to variable of front and rear brake line pressure, braking frictional coefficient, pressure to torque convert coefficient and so on. This formula can realize data exchange between braking system and control model, brake torque of front_left_wheel is below:
M=VARVAL (._ABS_left_front_brake_pressure_input)
*VARVAL(._truck_air_brakes_modify.brake_line_pressure)
* VARVAL (._truck_air_brakes_modify.load_sensitive_pressure_metering_front)
*._truck_air_brakes_modify.pvs_brake_mu
*._truck_air_brakes_modify.pvs_pressure_to_torque_cnvt
*STEP(varval(._truck_air_brakes_modify.left_front_wheel_omega), -0.0175,1,0.0175,-1)

3. ABS control model

There is an interface in ADAMS/Car that converts mechanistic model to S-FUNCTION, and then S-FUNCTION imported to control system, as S-FUNCTION has kinds of tools that can make model develop easier[2,3]. The mechanistic model in Simulink is in picture 3. Control loop will be formed with control model and input/output variable in ADAMS/Car, and control loop is showed in picture 4.



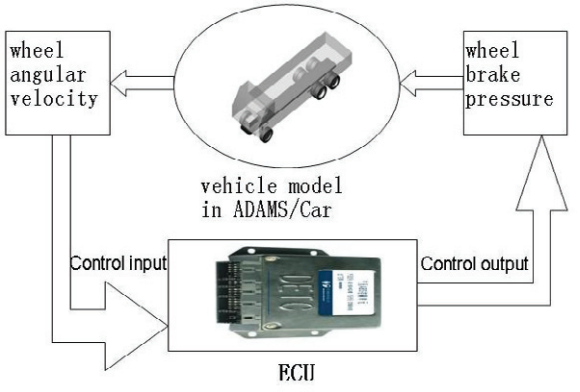


Fig. 3. vehicle model in simulink; Fig. 4. control loop.

ABS control system is established in Matlab/Simulink, and shows in picture 5. Wheel speed is input parameters of control system and in the meanwhile is output parameters of ADAMS model. Weighted coefficients of braking pressure are output parameters of control system and input parameters of ADAMS model. Wheel acceleration and slip ratio are control parameters of logic threshold for logic threshold control methods.
The basic process of control system is below: Real-time wheel angular velocity is transferred to control system, wheel rotational deceleration and slip rate are calculated according to the real-time wheel angular

velocity, and compared with default threshold to get logic result, and logic result is fed back to vehicle model to adjust braking pressure[4].

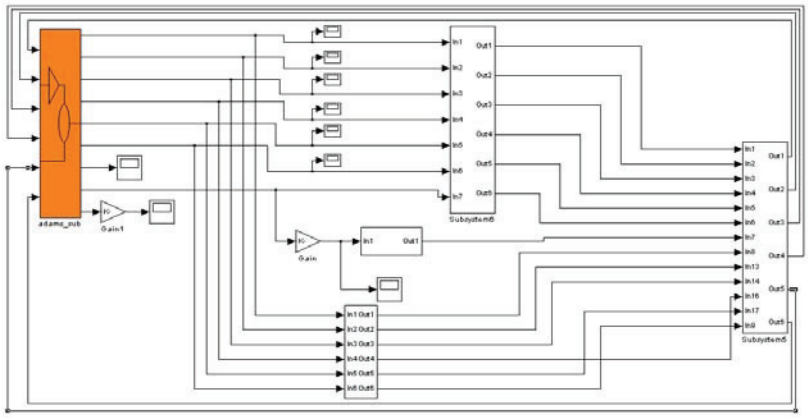


Fig. 5. ABS control system

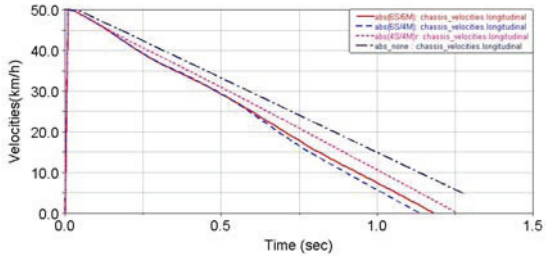
4. simulation & analysis

Simulation test of braking in straight line is conducted on bituminous pavement (friction coefficient is 0.8) with initial velocity of 50km/h, and emergency braking 100% severity of braking. Wheels are controlled directly should not lock and any part of the vehicle can not exceed the road with 3.7m[1]. Road adhesion coefficient utilization ε should be measured, and when maximum severity of braking divide by adhesion coefficient, road adhesion coefficient utilization will get:

$$\varepsilon = z / \varphi \tag{2}$$

And road adhesion coefficient utilization should not less than 0.75, simulation step is 0.01 and simulate time is 3s.

In order to analyse vehicle performance that based on different arrangement of ABS, simulation of 6 sensor 6 solenoid valve, 6 sensor 4 solenoid valve, 4 sensor 4 solenoid valve are conducted, and simulation results are in picture 6 to picture 9.



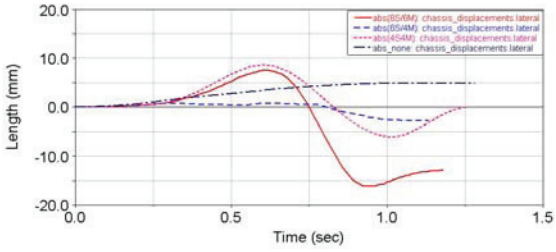
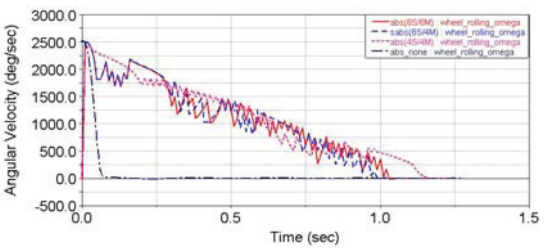


Fig. 6. wheel velocity; Fig. 7. lateral displacement.



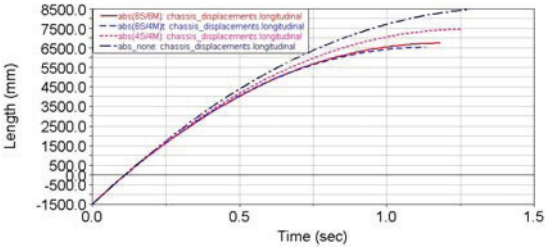


Fig. 8. wheel angular velocity; Fig. 9. braking displacement.

There is braking wave as with logic threshold control methods, but the wave is small. From picture 8, we can see phases of pressure keeping and frequency variation is in normal range.

Simulation data shows that logic threshold control is effective, as braking distance decreases and braking deceleration increases, adhesion coefficient utilization is more than 0.75 with ABS that meets the requirements of the national standard. From picture 7 and picture 8 we can see that wheels do not lock during braking and the vehicle is in the test road. Picture 6 and picture 9 shows that braking deceleration rises and braking distance reduces with ABS. ABS arrangement with 6S/6M and 6S/4M have advantage in longitudinal braking performance, and 4S/4M arrangement has better lateral performance. To sum up, ABS system can enhance braking performance compared with normal braking.

5. conclusions

The research of multi-body dynamics model and ABS control model base on wheel deceleration and slip rate are presented. ABS system with logic threshold control method can enhance vehicle's braking performance and has advantage on brake safety, so ABS system with logic threshold control has used widely on kinds of vehicles. Three different arrangement of ABS system can not obtain better lateral and longitudinal braking performance, so ABS technology of multi-axle truck need further research.

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